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A computer tool called SABER (Situation Assessment by Explanation-based Reasoning) is being developed by the Navy to assist decision makers involved in real time tactical decision making situations. The SABER work is being done as part of the TADMUS (TActical Decision Making Under Stress) project, funded by the Office of Naval Technology. SABER makes use of explanation-based reasoning (EBR) techniques to analyze data and interact with users.

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Development of the Situation Assessment by Explanation-Based Reasoning Tool

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Introduction

A computer tool called SABER (Situation Assessment By Explanation-based Reasoning) is being developed by the Navy to assist decision makers involved in real time tactical decision making situations. The SABER work is being done as part of the TADMUS (TActical Decision Making Under Stress) project, funded by the Office of Naval Technology. SABER makes use of an explanation-based reasoning (EBR) technique to analyze data and interact with users.

Problems arise in tactical situations when data needed for decisions have the following characteristics: (1) some of the data is incomplete or uncertain, (2) the volume of potentially relevant data is high, and (3) the data accumulates rapidly. These characteristics cause problems for human decision makers, and the problems are exacerbated when there are severe time constraints.

The problems are of two basic types. There are difficulties in being able to process the available information quickly enough, and there can be problems with cognitive biases or other cognitive difficulties. While it is a straightforward proposition that computers can assist in processing data quickly, there has been little work in the area of directly using computers to assist in overcoming cognitive problems.

The TADMUS project is generally concerned with exploring the kinds of biases or other cognitive problems that actually arise in tactical situations, and with trying to find ways of overcoming such problems. The two basic areas being looked at as sources of improvement are training and computer support systems. The SABER work is specifically focused on producing a computer support tool to improve the human decision making process. It is not intended to replace the decision making processes of the human decision makers.

A key element in this problem area is that it is necessary for people to handle reasoning with uncertainty in time constrained situations. These are situations in which there may not be a single correct analysis, but where it is desirable to achieve as good an analysis as possible because the consequences of mistakes can be serious. The SABER tool is expected to assist in the decision making by providing some of the reasoning, and by doing so at a faster rate than humans can do. It is also expected that as a result of using the EBR approach the tool can structure interactions with users in ways that can overcome some of the problems associated with

cognitive biases. In addition, a major emphasis has been put on developing a tool that can have its database and actual results easily modified by technicians who may not be experts either with computers or mathematics.

The SABER tool models one of the strategies we believe people use themselves in reasoning with uncertain or incomplete data. It is believed that the EBR approach is justified both because it can function in a variety of well-defined decision making situations, and because it reflects human decision making processes in those situations. SABER is expected to interact through a blackboard architecture with other decision support tools that will comprise a complete decision support system.

Development of SABER

The SABER tool was originally developed at NRaD as a vehicle for exploring ideas about explanation-based reasoning that were first discussed by Pratt (1987). The original implementation was based on a tool that had been developed by Hirst (1988). The NRaD work was initially done using Lisp in a Symbolics programming environment. SABER has recently been reimplemented to run both in HyperCard on Macintosh computers and in an environment called MetaCard which runs in Sun environments. The Sun implementation in particular is viewed as an advance since it allows SABER to run in the same environment as other parts of the overall DSS.

The EBR approach was first seen as a new way of dealing with computerized reasoning with uncertainty. The idea is to assemble available data into structures that attempt to explain the data in different ways. For instance, in the AAW setting there might be conflicting data about whether a given aircraft is friendly, neutral, or hostile. The SABER tool would construct separate, alternative explanations showing how the data could be accounted for in reaching each of those three conclusions. After constructing those explanations, the tool can then use a simple, heuristic approach to judge the relative strength of the three explanations. Further details can be found in (Hair et al, 1992) and (Hair and Pickslay, 1992).

In addition to the emphasis on reasoning with uncertainty, the SABER tool was developed as a highly interactive, standalone tool. The interactive features were incorporated with the idea of promoting ease of use. The tool was intended to operate in conjunction with other stand-alone tools through a blackboard architecture.

As the TADMUS project progressed, some of the ideas and emphases behind the SABER work changed. The point of view has developed that the new tools should look more to enhancing the user's own decision making processes than to exploring new ways for the computer itself to formulate answers. One result of that emphasis is that it is now an open question whether the SABER generated evaluation of the plausibility of explanations will even be shown to users. There is some thought that users may give too much credence to computer generated evaluations, and not use their own judgement to good advantage if the computer seems to be giving them an answer.

Another emphasis has been on the idea of modelling user decision strategies in the decision support tools. To that end we have established a mapping between the SABER tool and a decision-making strategy referred to as explanation-based decision making (Pennington and Hastie, 1988). That mapping is straightforward since the basic idea of the explanation-based decision making strategy is that the decision maker will combine

available data into explanations and reach a decision by evaluating the plausibility of the explanations. That process essentially describes what SABER does.

Discussion

The SABER tool uses the EBR technique to model one strategy believed to be used by people in decision making. However, the SABER approach is not limited to strictly following the human model. Thus, SABER will examine explanations that can justify all of the possible conclusions, whereas people generally appear to only consider a few of the most likely seeming explanations. By looking at all conclusions SABER avoids possible problems of missing ways of explaining data, and it exploits the ability of the computer to construct the necessary explanations quickly. By presenting all of the explanations to the user, it is believed that SABER will help prevent overlooking some of the possibilities and thereby help overcome some possible biasing problems. Of course, a limitation exists in that SABER can only be used effectively in situations where there are a fixed number of known possible conclusions.

Even though SABER constructs explanations to support each possible conclusion, it is able to do so in linear time unlike many other methods in common use. The method of building up explanations to account for several pieces of data simply draws out a partial explanation from each piece of data that points to each possible conclusion, and combines those pieces. The weighting of each of the composite explanations is done when those pieces are combined, so that the overall evaluation is done in linear time based on the number of pieces of data.

Ease of use in training SABER to reach correct conclusions is promoted by asking users to indicate how complete situations should be decided. The users do not deal at any point with specific weights for any data, or parts of data. Where users are entering entirely new data they are asked to indicate weights by means of the use of fuzzy terms rather than by supplying any numeric values. Thus, the only expertise looked for in the user is related to the user's own knowledge of the decision making scenario, not any knowledge of mathematical or computer theory.

The overall use of SABER is dependent on the actual time constraints existing at any given time. At the most immediate level the tool can always display the ordered conclusions and confidence levels. Where more time is available, additional information can be obtained about underlying assumptions.

The question remains as to whether SABER can be shown to improve human performance. Improvement is looked for in SABER's ability to handle more information at once and in the fact that it will not be subject to human biases. It is also thought that by modelling a strategy already familiar to users, the tool will be more readily understood and accepted by the users. However, it needs to be demonstrated that humans using a tool like SABER will benefit from such use.

The ability of SABER users to easily revise the knowledge base in a variety of ways is seen as an advance in this kind of tool. That ability acts as an

adjunct to the ability to train the tool and is a way of postponing obsolescence.

The ability of the user to train the tool and revise the knowledge base is also seen as important in increasing user confidence in the tool. It is expected that users who have actively engaged in training the tool will have reason to be confident in the tool's analysis, and at the same time will have an appreciation for the limitations of that analysis.

In general, we believe that human decision making can be improved through the use of tools like SABER, where the emphasis is on modelling the strategies actually used by people as a means of being able to directly influence when and how such strategies are used. We also believe that usability, and especially modifiability, by people who are not computer experts is extremely critical. Only if the actual users are able to have a direct impact on the results generated by the tool will the users have a full appreciation for what the tool is capable of, and only that kind of understanding can lead to successful use of the tool.

Conclusion

The SABER tool is being developed as part of an approach to improving human decision making in time constrained situations. We believe the tool offers benefits directly related to the fact that the tool models one of the strategies of decision making believed to be used by people. This approach should result in the tool being more easily understood and therefore more easily used and modified. The approach also lends itself to an ability to present information in a way that will be useful in overcoming possible cognitive biases. Thus, alternative explanations are always available and can be presented to users along with underlying assumptions, in ways that can positively influence the decision making process.

References

Hair, D.C. and Pickslay, K., "Development of Computer Support for Naturalistic Decision-Making", Technical Report 1558, Naval Command, Control and Ocean Surveillance Center, RDT&E Division, December, 1992.

Hair, D.C., Pickslay, K. & Chow, S.. Explanation-Based Decision Support in Real Time Situations, *4th International Conference on Tools With Artificial Intelligence*, pp. 22-25, Arlington, Virginia, 1992.

Hammond, K.R., Hamm, R.M., Grassia, J., and Pearson, T., 1987, Direct Comparison of the Efficacy of Intuitive and Analytical Cognition in Expert Judgement, *IEEE Transactions on Systems, Man, and Cybernetics*, 753-770.

Hirst, R.A., 1988. Uncertainty in Knowledge-Based Command Systems, Master's Thesis, University of Manchester, UK.

Klein, G.A., 1989. Recognition-Primed Decisions, in *Advances in Man Machine Systems Research 5*, Rouse, W.R. (ed.), J.A. Press, 47-92.

Pennington, N. and Hastie, R., 1988. Explanation-based Decision Making: The Effects of Memory Structure on Judgement, *Journal of Experimental Psychology: Learning, Memory, and Cognition 14*, 521-533.

Perrow, C., 1984, *Normal Accidents*, Basic Books.

Pratt, I., 1987. Explanatory Asymmetry, *Proceedings of Alvey KBS Club Explanation SIG 3rd Workshop*, 168-182, University of Surrey.